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EXAMINER	
HUBER, ROBERT T	

ART UNIT	PAPER NUMBER
2892	

MAIL DATE	DELIVERY MODE
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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/580,346	NAMBA ET AL.	
	Examiner	Art Unit	
	ROBERT HUBER	2892	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 25 March 2010.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-5,7,8 and 10-15* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-5,7,8 and 10-15* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on 25 May 2006 is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☒ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

3. Claims 1 -5, 7, 8, 10, 11 and 13 – 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Imai et al. (US 5,001,452, prior art of record) in view of Yoshida (US 6,340,393 B1, prior art of record) and Hasegawa et al. (US 2002/0127405 A1, prior art of record).

a. Regarding claim 1, **Imai discloses a diamond n-type semiconductor** (e.g. Example 1, being in col. 4, line 66) **comprising a first diamond semiconductor which has n-type conduction** (col. 4, line 68 – col. 5, line discloses forming an n-type diamond semiconductor layer, doped with sulfur, on

a diamond substrate) **and in which a distortion or defect is artificially formed** (as disclosed in Imai, the n-type layer is doped with dopants (S), and therefore a distortion is formed in the diamond semiconductor lattice due to the sulfur impurity. Furthermore, the patentability of a product does not depend on the method of production. See MPEP 2113),

wherein said first diamond semiconductor contains at least one kind of donor element of 5×10^{19} cm^{-3} or more in total (col. 2, lines 30 – 32 and Table 1 disclose a dopant concentration to be between 1×10^{12} cm^{-3} and 1×10^{21} cm^{-3}, and therefore anticipates the claimed value)

wherein said first diamond semiconductor has an n-type dopant concentration adjusted by vapor-phase growth (col. 5, line 3 discloses forming the n-type dopant concentration layer by CVD, which is a vapor phase deposition. Furthermore, the patentability of a product does not depend on the method of production. See MPEP 2113.) **such that an electron concentration of said first diamond semiconductor exhibits a negative correlation with temperature, in a temperature range having a width of 100°C or more and included within a temperature region from 0°C to 300°C** (see comment below regarding the properties of the device, which follows claim 5).

Imai is silent with respect to said first diamond semiconductor containing an impurity element other than the donor element, the contained amount of the impurity element being lower than the total contained amount of the donor element

Yoshida discloses a combining a second impurity element together with the donor element in a diamond semiconductor (col. 2, lines 51 – 52, col. 5, lines 59 – 61, and col. 5, lines 65 - 67), **the contained amount of the impurity element being lower than the total contained amount of the donor element** (e.g. col. 2, lines 57 – 62 and col. 3, lines 5 - 10 discloses forming the impurity (acceptor) and donor in the diamond semiconductor with a atomic density ratio of 1:2 or 1:3, such that the amount of donor material is 2 - 3 times more than the impurity (acceptor) material).

It would have been obvious for one of ordinary skill in the art at the time the invention was made to modify the device of Imai to include an impurity element along with the donor element, with the amount of impurity element less than the amount of donor element, since it was known that one may combine impurity elements with donor elements into diamond semiconductor materials, as taught by Yoshida. One would have been motivated to add an impurity element with a donor element with the relationship as claimed since it allows a stabilization of the semiconductor layer with a large dopant density (as discussed in Yoshida, col. 2, lines 51 - 53).

Imai and Yoshida are silent with respect to disclosing the impurity element is Si (silicon) locally existing the first diamond semiconductor.

Hasegawa discloses that silicon can be used as an impurity element when doping semiconductor diamond (paragraphs [0037] – [0038]). **The doping of Si into the diamond semiconductor may be considered to be**

"*locally existing*" since it is doped as an impurity element into the substrate.

It would have been obvious for one of ordinary skill in the art at the time the invention was made to modify the device of Imai in view of Yoshida, such that the other impurity element is silicon since Hasegawa discloses that silicon can be used in such concentrations to dope semiconductor diamond with a p-type material, and Yoshida discloses that a combination of n-type and p-type materials may be doped into a diamond semiconductor in order to stabilize the material when high n-type densities are used (col. 2, lines 50 - 52 of Yoshida). One would be motivated to use silicon as an impurity element since silicon was a commonly used element in the semiconductor industry and is readily available with well-known properties, and one skilled in the art may adjust the band-gap and electrical properties of the semiconductor to using Si to optimize the semiconductor properties, such as conductivity, for a desired circuit, as discussed by Hasegawa (¶ [0037]).

Regarding the limitation of the silicon impurity "*<u>for</u> restraining the deterioration of diamond crystallinity caused by the doping of the donor element*", the examiner finds this to be a statement of intended use or inherent properties. Since the device of Imai in view of Yoshida and Hasegawa discloses the claimed structure (i.e. diamond semiconductor doped with a donor element and an impurity element of Si), it is rendered obvious that the Si will restrain the deterioration of the diamond

crystallinity. It has been held that when the prior art discloses the <u>structure</u> of the claimed invention, a prima facie case of anticipation or obviousness of the properties of the device has been established. See MPEP 2112.01.

i. Claim 2, **Imai in view of Yoshida and Hasegawa disclose a diamond n-type semiconductor according to claim 1, as cited above, wherein said first diamond semiconductor has a Hall coefficient exhibiting a positive correlation with temperature, in the temperature range** (see below)

ii. Claim 3, **Imai in view of Yoshida and Hasegawa disclose a diamond n-type semiconductor according to claim 1, as cited above, wherein the temperature range included within the temperature region from 0°C to 300°C has a width of over 200°C or more** (see below)

iii. Claim 4, **Imai in view of Yoshida and Hasegawa disclose a diamond n-type semiconductor according to claim 1, as cited above, wherein said first diamond semiconductor has a resistivity of 500 Ωcm or less at a temperature within the temperature region from 0°C to 300°C** (see below)

iv. Claim 5, **Imai in view of Yoshida and Hasegawa disclose a diamond n-type semiconductor according to claim 1, as cited above, wherein the electron concentration of said first diamond semiconductor is always 10^{16} cm^{-3} or more in the temperature region from 0°C to 300°C** (see below)**.**

Regarding claims 1 – 5, the device of Example 1 of Imai contains an n-type diamond semiconductor layer containing a Sulfur dopant concentration, as disclosed in col. 2, lines 30 – 32 and Table 1, which resides on a diamond substrate, as disclosed in col. 5, lines 1 - 2. Since the device of Imai in view of Yoshida and Hasegawa meets the structural limitations of the claimed invention of the Applicant, the properties of the applicant's invention, such as the temperature dependence of the electron concentration and Hall coefficient as claimed in claims 1 - 5, are obvious or inherent to the device of Imai in view of Yoshida and Hasegawa. See MPEP 2112.01.

b. Regarding claim 7, **Imai in view of Yoshida and Hasegawa disclose the diamond semiconductor according to claim 1, as cited above. Imai and Yoshida are silent with respect to explicitly disclosing said first diamond semiconductor contains at least P (phosphorus) as the donor element. However, Imai does acknowledge that phosphorus may be used as a dopant in semiconductors** (Imai: col. 2, lines 20 - 21).

Hasegawa discloses that both phosphorus and sulfur can be used as n-type dopants in diamond semiconductors (e.g. ¶ [0032] discloses the use of sulfur, and ¶ [0037] discloses that phosphorus may also be used).

It would have been obvious for one of ordinary skill in the art at the time the invention was made to modify the device of Imai in view of Yoshida such that phosphorus was uses as the dopant in the n-type diamond semiconductor layer since Imai discloses that sulfur is used as the n-type dopant, and Hasegawa discloses that both sulfur and phosphorus may be used as the n-type dopant in the diamond semiconductor. One would have been motivated to use phosphorus instead of sulfur in order to adjust the band-gap and electrical properties of the semiconductor to optimize the semiconductor properties, such as conductivity, for a desired circuit, as discussed by Hasegawa (¶ [0037]).

c. Regarding claim 8, **Imai in view of Yoshida and Hasegawa disclose a diamond n-type semiconductor according to claim 1, as cited above, wherein said first diamond semiconductor contains at least S (sulfur) as the donor element** (Imai: e.g. as disclosed in col. 4, line 68).

d. Regarding claim 10, **Imai in view of Yoshida and Hasegawa disclose a diamond n-type semiconductor according to claim 1, as cited above, wherein the contained amount of Si is 1 x 10^{17} cm^{-3} or more** (Hasegawa: ¶ [0037] – [0038]).

e. Regarding claim 11, **Imai in view of Yoshida and Hasegawa disclose a diamond n-type semiconductor according to claim 1, wherein said first diamond semiconductor is monocrystal diamond** (Imai: e.g. col. 2, line 28 discloses the formation of the first diamond semiconductor by "single-crystal" growth).

f. Regarding claim 13, **Imai in view of Yoshida and Hasegawa disclose a semiconductor device at least partly employing a diamond n-type semiconductor according to claim 1** (Imai: as disclosed in col. 4, lines 38 - 44).

g. Regarding claim 14, **Imai in view of Yoshida and Hasegawa disclose the diamond n-type semiconductor according to claim 1, as cited above. Imai and Hasegawa are silent with respect to the device being used in at least an electron emitting part of an electron emitting device.**

Yoshida discloses that diamond semiconductor devices can be used as an electron emitter (col. 5, lines 18 – 19).

It would have been obvious for one of ordinary skill in the art at the time the invention was made to use the diamond semiconductor of Imai in view of Hasegawa as an electron emitter since Yoshida discloses that such semiconductor devices can be used as electron emitters. One would be

motivated to use the devices in such a manner since a low resistivity exists in such devices, creating an efficient electron emitter.

h. Regarding claim 15, **Imai in view of Yoshida and Hasegawa disclose a method of manufacturing a diamond n-type semiconductor according to claim 1, as cited above, said method comprising the steps of:**

preparing a diamond substrate (Imai: substrate disclosed in col. 5, line 1); **and**

epitaxially growing a diamond semiconductor on said diamond substrate by vapor phase growth (Imai: col. 4, line 68 – col. 5, line 3 discloses forming the diamond semiconductor by CVD (chemical vapor deposition) and col. 2, lines 25 – 26 disclose forming the diamond semiconductor by vapor phase growth. Col. 5, line 8 discloses the diamond semiconductor to be epitaxial), **whereby said diamond semiconductor has n-type conduction** (Imai: e.g. as disclosed in col. 5, lines 7 - 10) **and has a distortion or defect which is artificially formed therein** (as disclosed in Imai, the n-type layer is doped with dopants (S), and therefore a distortion is formed in the diamond semiconductor lattice due to the impurity).

Imai is silent with respect to disclosing artificially introducing an impurity element other than a donor element to said diamond substrate while growing the diamond semiconductor.

Yoshida discloses artificially introducing an impurity element other than a donor element to a diamond substrate while growing the diamond semiconductor (e.g. col. 2, lines 51 – 52, col. 5, lines 59 – 61, and col. 5, lines 65 - 67).

It would have been obvious for one of ordinary skill in the art at the time the invention was made to modify the method of Imai such that an impurity element other than the donor (dopant) element is introduced to the diamond substrate while growing the diamond semiconductor since Yoshida discloses that the addition of impurities while growing diamond semiconductors on diamond substrates can be advantageous. One would have been motivated to add the impurity to the doped diamond semiconductor because it would aid in the stabilization of the diamond semiconductor layer with a large dopant density (as discussed in Yoshida, col. 2, lines 51 - 53).

Imai and Yoshida are silent with respect to disclosing the impurity element is Si (silicon).

Hasegawa discloses that silicon can be used as an impurity element when doping semiconductor diamond (paragraphs [0037] – [0038]).

It would have been obvious for one of ordinary skill in the art at the time the invention was made to modify the device of Imai in view of Yoshida, such that the other impurity element is silicon since Hasegawa discloses that silicon can be used in such concentrations to dope semiconductor diamond with a p-type material, and Yoshida discloses that a combination of n-type and p-type

materials may be doped into a diamond semiconductor in order to stabilize the material when high n-type densities are used (col. 2, lines 50 - 52 of Yoshida). One would be motivated to use silicon as an impurity element since silicon was a commonly used element in the semiconductor industry and is readily available with well-known properties, and one skilled in the art may adjust the band-gap and electrical properties of the semiconductor to using Si to optimize the semiconductor properties, such as conductivity, for a desired circuit, as discussed by Hasegawa (¶ [0037]).

4. Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over Imai in view of Yoshida and Hasegawa, as applied to claim 1 above, and in further view of Shiomi et al. (US 5,252,840, prior art of record). **Imai in view of Yoshida and Hasegawa disclose a diamond n-type semiconductor according to claim 1, but are silent with respect to disclosing the device further comprises a second diamond semiconductor provided adjacent to said first diamond semiconductor and turned out to be n-type, wherein said second diamond semiconductor has an electron concentration exhibiting a negative correlation with temperature and a Hall coefficient not exhibiting a positive correlation with temperature, in the temperature range.**

Shiomi discloses that a second diamond semiconductor may be provided adjacent to a first diamond semiconductor (e.g. figure 1(b), second diamond

semiconductor 3, disclosed in col. 9, lines 46 – 48, adjacent to first diamond semiconductor 2, disclosed in col. 8, lines 21 - 22),

wherein said second diamond semiconductor has an electron concentration exhibiting a negative correlation with temperature and a Hall coefficient not exhibiting a positive correlation with temperature, in the temperature range (col. 5, lines 16 – 24 disclose the structural characteristics of the device and layers. Since the device of Shiomi meets the structural limitations of the claimed invention of the Applicant, the properties of the applicant's invention, such as the temperature dependence of the electron concentration and Hall coefficient as claimed in claim 12, are presumed inherent to the device of Shiomi. See MPEP 2112.01).

It would have been obvious for one of ordinary skill in the art at the time the invention was made to modify the device of Imai in view of Yoshida and Hasegawa such that a second diamond semiconductor layer was adjacent to the first diamond semiconductor layer, with the claimed properties, since Shiomi discloses that one may form such structures to achieve desired conduction properties of the device (col. 9, lines 61 – 68). One would have been motivated to form a second diamond semiconductor layer adjacent to the first diamond semiconductor layer in order to allow charge carrier diffusion from the first layer into the second layer, thereby altering the conduction properties of the device, as disclosed by Shiomi (col. 5, line 16 – 21).

Although Shiomi is silent with respect to the second semiconductor being n-type, Shiomi discloses the first and second diamond semiconductor layers to

be p-type doped diamond semiconductor (col. 8, line 22 and col. 9, lines 48 - 49), **and it is well-known in the art that one may interchange p-type and n-type doping to achieve a desired charge carrier concentration of either holes or electrons** (e.g. as discussed in Shiomi, col. 1, lines 51 – 55, and Imai, col. 1, lines 16 - 24). **One would have been motivated to substitute n-type doping for p-type doping in the first and second layers of Shiomi in order to create an n-type device, which would allow one to form complimentary circuits well-known in the semiconductor art (e.g. pn junctions).**

Response to Arguments

5. Applicant's arguments filed on March 25, 2009 have been fully considered but they are not persuasive. At present, the prior art of Imai, Yoshida, and Hasegawa remains commensurate to the scope of the claims as stated by the Applicant within the context of the claim language and as broadly interpreted by the Examiner [MPEP 2111], which is elucidated and expounded upon above. In response to Applicants arguments drawn to the amendment "*the impurity element is Si locally existing in said first diamond semiconductor*", the prior art of Imai in view of Yoshida and Hasegawa renders obvious such a limitation. In particular, the prior art of Hasegawa discloses doping a diamond semiconductor with Silicon at a concentration of $1x10^{16}$ – $1x10^{21}$ cm^{-3}, which anticipates the limitation of the diamond semiconductor being doped with $1x10^{17}$ cm^{-3} of Si (as recited in claims 1 and 10). Therefore, Hasegawa teaches the limitation of doping the diamond semiconductor with Si, which may be considered as "*locally existing*" since the

impurity and dopant materials, and concentration, are disclosed (e.g. see pg 7 of Remarks regarding the phrase "*locally existing*", which states that "w*hen both Si and a donor element are doped with a diamond, under specific conditions, as recited in claim 1, "Si" locally exists in the n-type diamond semiconductor*"). Since Imai in view of Yoshida and Hasegawa render obvious the doping of a diamond semiconductor with an Si impurity and a donor element, as recited in claim 1, the limitation of the Si existing "*locally*" is also rendered obvious.

6. In response to applicant's argument that the examiner's conclusion of obviousness is based upon improper hindsight reasoning (e.g. the combination of Hasegawa with Imai, as recited on pg. 8 of Remarks), it must be recognized that any judgment on obviousness is in a sense necessarily a reconstruction based upon hindsight reasoning. But so long as it takes into account only knowledge which was within the level of ordinary skill at the time the claimed invention was made, and does not include knowledge gleaned only from the applicant's disclosure, such a reconstruction is proper. See *In re McLaughlin*, 443 F.2d 1392, 170 USPQ 209 (CCPA 1971). In particular, the Examiner has stated that one would be motivated to dope the diamond semiconductor substrate with Si in order to control the diamond conductivity, which is disclosed by the prior art of Hasegawa to be a motivational reason (¶ [0037]). Therefore, since the prior art gives a motivation, there has been no hindsight reason used by the Examiner.

7. Regarding the Applicant's argument that Yoshida teaches a relationship between the donor element and the impurity element, but that Si cannot become an acceptor element (pg. 8 of Remarks), the Applicant has not clearly stated the reasoning behind such an argument. The Applicant argues that Si cannot be used as an acceptor element in Yoshida, but does not clearly support such an argument. Rather, the Applicant merely states that this is the case. The Attorney's argument that Si cannot be used as an acceptor element, and thus that Hasegawa and Yoshida may not be combined, may be regarded as speculation since it has not been shown conclusively that Si cannot be used in the method and device of Yoshida, and an argument by an Attorney is not the kind of factual evidence that is required to rebut a prima facie case of obviousness. See MPEP 2145.

8. In responds to the amendment wherein the Si is used as "*a material for restraining the deterioration of diamond crystallinity caused by the doping of the donor element*", the Examiner regards this limitation as a statement of intended use or inherent properties of the material and device. The prior art of Imai in view of Yoshida and Hasegawa render obvious the structure of the claimed invention, as cited above with respect to claim 1, and it has been held that when the prior art discloses the structure of the claimed invention, a prima facie case of anticipation or obviousness of the properties of the device, such as the restraining of the deterioration of the diamond crystallinity, has been established. See MPEP 2112.01.

Conclusion

9. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to ROBERT HUBER whose telephone number is (571)270-3899. The examiner can normally be reached on Monday - Friday (11am - 7pm EST).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Thao Le can be reached on (571) 272-1708. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Thao X Le/
Supervisory Patent Examiner, Art Unit 2892

/Robert Huber/
Examiner, Art Unit 2892
June 11, 2010